CMOS Digital Integrated Circuits Silicon Monolithic

# TC74VCX574FT

## 1. Functional Description

- Low-Voltage Octal D-Type Flip-Flop with 3.6-V Tolerant Inputs and Outputs

## 2. General

The TC74VCX574FT is a high performance CMOS octal D-type flip-flop which is guaranteed to operate from 1.2 V to 3.6 V. Designed for use in 1.5 V, 1.8 V, 2.5 V or 3.3 V systems, it achieves high speed operation while maintaining the CMOS low power dissipation.

It is also designed with over voltage tolerant inputs and outputs up to 3.6 V.

This 8 bit D-type flip-flop is controlled by a clock input (CK) and an output enable input ($\overline{OE}$). When the $\overline{OE}$ input is high, the eight outputs are in a high impedance state.

All inputs are equipped with protection circuits against static discharge.

## 3. Features

(1) Wide operating temperature range: $T_{opr}$ = -40 to 125 °C (Note 1)

(2) Low-voltage operation: $V_{CC}$ = 1.2 to 3.6 V

(3) High-speed operation: $t_{pd}$ = 4.2 ns (max) ($V_{CC}$ = 3.0 to 3.6 V)
$t_{pd}$ = 4.8 ns (max) ($V_{CC}$ = 2.3 to 2.7 V)
$t_{pd}$ = 9.6 ns (max) ($V_{CC}$ = 1.65 to 1.95 V)
$t_{pd}$ = 19.2 ns (max) ($V_{CC}$ = 1.4 to 1.6 V)
$t_{pd}$ = 48.0 ns (max) ($V_{CC}$ = 1.2 V)

(4) Output current: $I_{OH}/I_{OL}$ = ±24 mA (min) ($V_{CC}$ = 3.0 V)
$I_{OH}/I_{OL}$ = ±18 mA (min) ($V_{CC}$ = 2.3 V)
$I_{OH}/I_{OL}$ = ±6 mA (min) ($V_{CC}$ = 1.65 V)
$I_{OH}/I_{OL}$ = ±2 mA (min) ($V_{CC}$ = 1.4 V)

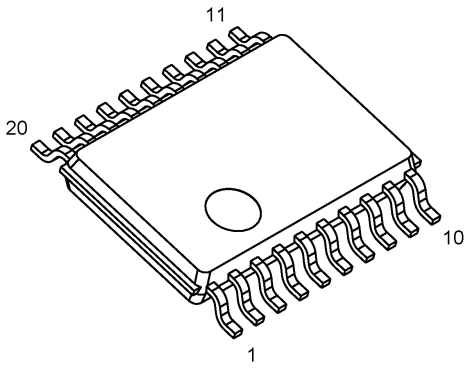
(5) Latch-up performance: -300 mA

(6) ESD performance: Human Body Model ≥ ±2000 V

(7) 3.6 V tolerant function and power-down protection provided on all inputs and outputs.

Note 1: Operating Range spec of $T_{opr}$ = -40 °C to 125 °C is applicable only for the products which manufactured after April 2020.

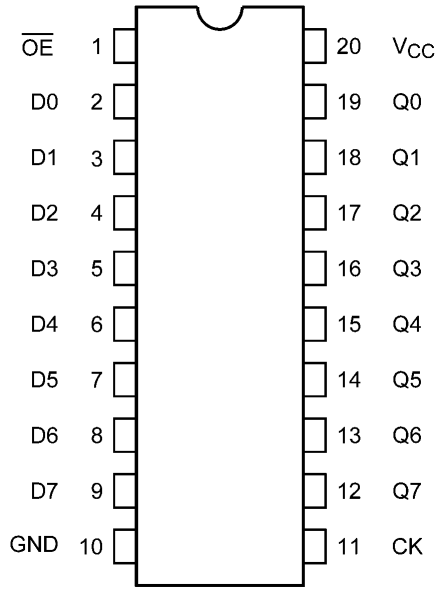
## 4. Packaging




TSSOP20

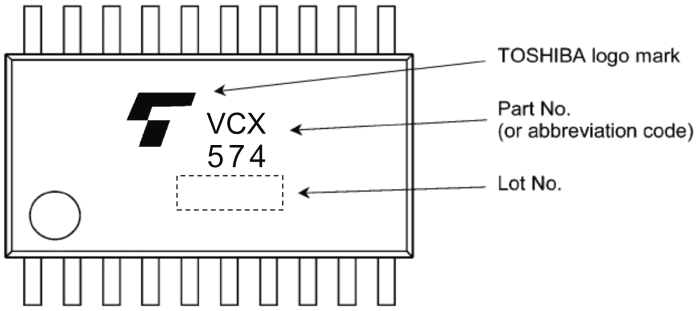
Start of commercial production
2020-04

## 5. Pin Assignment

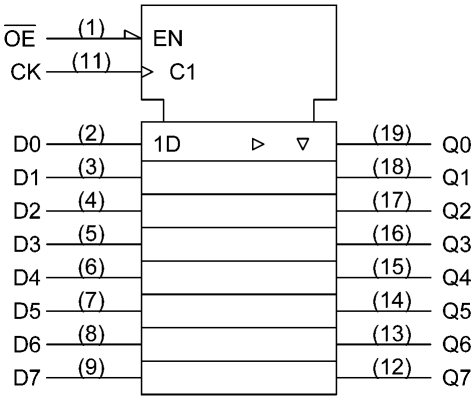



(top view)

## 6. Marking




## 7. IEC Logic Symbol

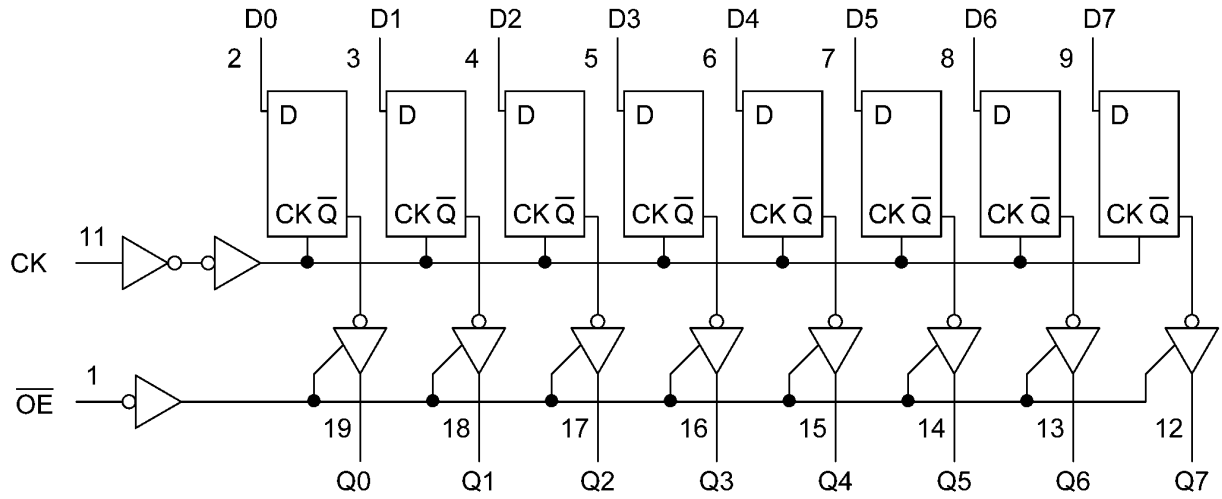


## 8. Truth Table

| Inputs | | | Outputs |
|---|---|---|---|
| $\overline{OE}$ | CK | D | |
| H | X | X | Z |
| L | ↓ | X | Qn |
| L | ↑ | L | L |
| L | ↑ | H | H |

X: Don't care
Z: High impedance
$Q_n$: No change

## 9. System Diagram



## 10. Absolute Maximum Ratings (Note)

| Characteristics | Symbol | Note | Rating | Unit |
|---|---|---|---|---|
| Supply voltage | $V_{CC}$ | | -0.5 to 4.6 | V |
| Input voltage | $V_{IN}$ | | -0.5 to 4.6 | V |
| Output voltage | $V_{OUT}$ | (Note 1) | -0.5 to 4.6 | V |
| | | (Note 2) | -0.5 to $V_{CC}$ + 0.5 | |
| Input diode current | $I_{IK}$ | | -50 | mA |
| Output diode current | $I_{OK}$ | (Note 3) | ±50 | mA |
| Output current | $I_{OUT}$ | | ±50 | mA |
| Power dissipation | $P_D$ | (Note 4) | 180 | mW |
| $V_{CC}$/ground current | $I_{CC}/I_{GND}$ | | ±100 | mA |
| Storage temperature | $T_{stg}$ | | -65 to 150 | °C |

Note: Exceeding any of the absolute maximum ratings, even briefly, lead to deterioration in IC performance or even destruction.
Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings and the operating ranges.
Please design the appropriate reliability upon reviewing the Toshiba Semiconductor Reliability Handbook (“Handling Precautions”/“Derating Concept and Methods”) and individual reliability data (i.e. reliability test report and estimated failure rate, etc).

Note 1: Output in OFF state.
Note 2: High (H) or Low (L) state. $I_{OUT}$ absolute maximum rating must be observed.
Note 3: $V_{OUT}$ < GND, $V_{OUT}$ > $V_{CC}$
Note 4: 180 mW in the range of $T_a$ = -40 to 85 °C. From $T_a$ = 85 to 125 °C a derating factor of -3.25 mW/°C shall be applied until 50 mW.

## 11. Operating Ranges (Note)

| Characteristics | Symbol | Note | Rating | Unit |
|---|---|---|---|---|
| Supply voltage | $V_{CC}$ | | 1.2 to 3.6 | V |
| Input voltage | $V_{IN}$ | | -0.3 to 3.6 | V |
| Output voltage | $V_{OUT}$ | (Note 1) | 0 to 3.6 | V |
| | | (Note 2) | 0 to $V_{CC}$ | |
| Output current | $I_{OH}$,$I_{OL}$ | (Note 3) | ±24 | mA |
| | | (Note 4) | ±18 | |
| | | (Note 5) | ±6 | |
| | | (Note 6) | ±2 | |
| Operating temperature | $T_{opr}$ | (Note 7) | -40 to 125 | °C |
| Input rise and fall times | dt/dv | (Note 8) | 0 to 10 | ns/V |

Note: The operating ranges must be maintained to ensure the normal operation of the device.
Unused inputs must be tied to either $V_{CC}$ or GND.

Note 1: Output in OFF state.
Note 2: High (H) or Low (L) state.
Note 3: $V_{CC}$ = 3.0 to 3.6 V
Note 4: $V_{CC}$ = 2.3 to 2.7 V
Note 5: $V_{CC}$ = 1.65 to 1.95 V
Note 6: $V_{CC}$ = 1.4 to 1.6 V
Note 7: Operating Range spec of $T_{opr}$ = -40 °C to 125 °C is applicable only for the products which manufactured after April 2020.
Note 8: $V_{IN}$ =0.8 to 2.0 V , $V_{CC}$ = 3.0 V

## 12. Electrical Characteristics

### 12.1. DC Characteristics (Unless otherwise specified, $T_a$ = -40 to 85 °C)

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| High-level input voltage | $V_{IH}$ | — | | 1.2 to 1.4 | $V_{CC}$ × 0.8 | — | V |
| | | | | 1.4 to 1.65 | $V_{CC}$ × 0.65 | — | |
| | | | | 1.65 to 2.3 | $V_{CC}$ × 0.65 | — | |
| | | | | 2.3 to 2.7 | 1.6 | — | |
| | | | | 2.7 to 3.6 | 2.0 | — | |
| Low-level input voltage | $V_{IL}$ | — | | 1.2 to 1.4 | — | $V_{CC}$ × 0.05 | V |
| | | | | 1.4 to 1.65 | — | $V_{CC}$ × 0.05 | |
| | | | | 1.65 to 2.3 | — | $V_{CC}$ × 0.2 | |
| | | | | 2.3 to 2.7 | — | 0.7 | |
| | | | | 2.7 to 3.6 | — | 0.8 | |
| High-level output voltage | $V_{OH}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OH}$ = -100 μA | 1.2 | $V_{CC}$ - 0.1 | — | V |
| | | | | 1.4 to 1.65 | $V_{CC}$ - 0.2 | — | |
| | | | | 1.65 to 3.6 | $V_{CC}$ - 0.2 | — | |
| | | | $I_{OH}$ = -2 mA | 1.4 | 1.05 | — | |
| | | | $I_{OH}$ = -6 mA | 1.65 | 1.25 | — | |
| | | | | 2.3 | 2.0 | — | |
| | | | $I_{OH}$ = -12 mA | 2.3 | 1.8 | — | |
| | | | | 2.7 | 2.2 | — | |
| | | | $I_{OH}$ = -18 mA | 2.3 | 1.7 | — | |
| | | | | 3.0 | 2.4 | — | |
| | | | $I_{OH}$ = -24 mA | 3.0 | 2.2 | — | |
| Low-level output voltage | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OL}$ = 100 μA | 1.2 | — | 0.05 | V |
| | | | | 1.4 to 1.65 | — | 0.05 | |
| | | | | 1.65 to 3.6 | — | 0.2 | |
| | | | $I_{OL}$ = 2 mA | 1.4 | — | 0.35 | |
| | | | $I_{OL}$ = 6 mA | 1.65 | — | 0.3 | |
| | | | $I_{OL}$ = 12 mA | 2.3 | — | 0.4 | |
| | | | | 2.7 | — | 0.4 | |
| | | | $I_{OL}$ = 18 mA | 2.3 | — | 0.6 | |
| | | | | 3.0 | — | 0.4 | |
| | | | $I_{OL}$ = 24 mA | 3.0 | — | 0.55 | |
| Input leakage current | $I_{IN}$ | $V_{IN}$ = 0 to 3.6 V | | 1.2 to 3.6 | — | ±5.0 | μA |
| 3-state output OFF-state leakage current | $I_{OZ}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$<br>$V_{OUT}$ = 0 to 3.6 V | | 1.2 to 3.6 | — | ±10.0 | μA |
| Power-OFF leakage current | $I_{OFF}$ | $V_{IN}$/$V_{OUT}$ = 0 to 3.6 V | | 0 | — | 10.0 | μA |
| Quiescent supply current | $I_{CC}$ | $V_{IN}$ = $V_{CC}$ or GND | | 1.2 to 3.6 | — | 20.0 | μA |
| | | $V_{CC}$ ≤ ($V_{IN}$/$V_{OUT}$) ≤ 3.6 V | | 1.2 to 3.6 | — | ±20.0 | |
| | $\Delta I_{CC}$ | $V_{IH}$ = $V_{CC}$ - 0.6 V<br>(per input) | | 2.7 to 3.6 | — | 750 | μA |

## 12.2. DC Characteristics (Note) (Unless otherwise specified, $T_a$ = -40 to 125 °C)

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| High-level input voltage | $V_{IH}$ | — | | 1.2 to 1.4 | $V_{CC}$ × 0.8 | — | V |
| | | | | 1.4 to 1.65 | $V_{CC}$ × 0.65 | — | |
| | | | | 1.65 to 2.3 | $V_{CC}$ × 0.65 | — | |
| | | | | 2.3 to 2.7 | 1.6 | — | |
| | | | | 2.7 to 3.6 | 2.0 | — | |
| Low-level input voltage | $V_{IL}$ | — | | 1.2 to 1.4 | — | $V_{CC}$ × 0.05 | V |
| | | | | 1.4 to 1.65 | — | $V_{CC}$ × 0.05 | |
| | | | | 1.65 to 2.3 | — | $V_{CC}$ × 0.2 | |
| | | | | 2.3 to 2.7 | — | 0.7 | |
| | | | | 2.7 to 3.6 | — | 0.8 | |
| High-level output voltage | $V_{OH}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OH}$ = -100 μA | 1.2 | $V_{CC}$ - 0.1 | — | V |
| | | | | 1.4 to 1.65 | $V_{CC}$ - 0.2 | — | |
| | | | | 1.65 to 3.6 | $V_{CC}$ - 0.2 | — | |
| | | | $I_{OH}$ = -2 mA | 1.4 | 1.05 | — | |
| | | | $I_{OH}$ = -6 mA | 1.65 | 1.25 | — | |
| | | | | 2.3 | 2.0 | — | |
| | | | $I_{OH}$ = -12 mA | 2.3 | 1.8 | — | |
| | | | | 2.7 | 2.2 | — | |
| | | | $I_{OH}$ = -18 mA | 2.3 | 1.6 | — | |
| | | | | 3.0 | 2.4 | — | |
| | | | $I_{OH}$ = -24 mA | 3.0 | 2.2 | — | |
| Low-level output voltage | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OL}$ = 100 μA | 1.2 | — | 0.05 | V |
| | | | | 1.4 to 1.65 | — | 0.05 | |
| | | | | 1.65 to 3.6 | — | 0.2 | |
| | | | $I_{OL}$ = 2 mA | 11.4 | — | 0.35 | |
| | | | $I_{OL}$ = 6 mA | 1.65 | — | 0.3 | |
| | | | $I_{OL}$ = 12 mA | 2.3 | — | 0.4 | |
| | | | | 2.7 | — | 0.4 | |
| | | | $I_{OL}$ = 18 mA | 2.3 | — | 0.8 | |
| | | | | 3.0 | — | 0.4 | |
| | | | $I_{OL}$ = 24 mA | 3.0 | — | 0.55 | |
| Input leakage current | $I_{IN}$ | $V_{IN}$ = 0 to 3.6 V | | 1.2 to 3.6 | — | ±20.0 | μA |
| 3-state output OFF-state leakage current | $I_{OZ}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$<br>$V_{OUT}$ = 0 to 3.6 V | | 1.2 to 3.6 | — | ±40.0 | μA |
| Power-OFF leakage current | $I_{OFF}$ | $V_{IN}$/$V_{OUT}$ = 0 to 3.6 V | | 0 | — | 40.0 | μA |
| Quiescent supply current | $I_{CC}$ | $V_{IN}$ = $V_{CC}$ or GND | | 1.2 to 3.6 | — | 80.0 | μA |
| | | $V_{CC}$ ≤ ($V_{IN}$/$V_{OUT}$) ≤ 3.6 V | | 1.2to 3.6 | — | ±80.0 | |
| | $\Delta I_{CC}$ | $V_{IH}$ = $V_{CC}$ - 0.6 V<br>(per input) | | 2.7 to 3.6 | — | 1.5 | mA |

Note: Operating Range spec of $T_{opr}$ = -40 °C to 125 °C is applicable only for the products which manufactured after April 2020.

## 12.3. AC Characteristics (Unless otherwise specified, $T_a$ = -40 to 85 °C)

| Characteristics | Symbol | Note | Test Condition | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| Maximum clock frequency | $f_{MAX}$ | | See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1 | 1.2 | 40 | — | MHz |
| | | | | 1.5 ± 0.1 | 80 | — | |
| | | | | 1.8 ± 0.15 | 100 | — | |
| | | | | 2.5 ± 0.2 | 200 | — | |
| | | | | 3.3 ± 0.3 | 250 | — | |
| Propagation delay time (CK-Q) | $t_{PLH}$,$t_{PHL}$ | | See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1 | 1.2 | 1.5 | 48.0 | ns |
| | | | | 1.5 ± 0.1 | 1.0 | 19.2 | |
| | | | | 1.8 ± 0.15 | 1.5 | 9.6 | |
| | | | | 2.5 ± 0.2 | 0.8 | 4.8 | |
| | | | | 3.3 ± 0.3 | 0.6 | 4.2 | |
| 3-state output enable time | $t_{PZL}$,$t_{PZH}$ | | See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.2, Table 12.8.1 | 1.2 | 1.5 | 49.0 | ns |
| | | | | 1.5 ± 0.1 | 1.0 | 19.6 | |
| | | | | 1.8 ± 0.15 | 1.5 | 9.8 | |
| | | | | 2.5 ± 0.2 | 0.8 | 5.5 | |
| | | | | 3.3 ± 0.3 | 0.6 | 4.5 | |
| 3-state output disable time | $t_{PLZ}$,$t_{PHZ}$ | | See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.2, Table 12.8.1 | 1.2 | 1.5 | 32.5 | ns |
| | | | | 1.5 ± 0.1 | 1.0 | 13.0 | |
| | | | | 1.8 ± 0.15 | 1.5 | 6.5 | |
| | | | | 2.5 ± 0.2 | 0.8 | 3.6 | |
| | | | | 3.3 ± 0.3 | 0.6 | 3.3 | |
| Minimum pulse width (CK) | $t_{w(L)}$,$t_{w(H)}$ | | See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1 | 1.2 | 24.0 | — | ns |
| | | | | 1.5 ± 0.1 | 8.0 | — | |
| | | | | 1.8 ± 0.15 | 4.0 | — | |
| | | | | 2.5 ± 0.2 | 1.5 | — | |
| | | | | 3.3 ± 0.3 | 1.5 | — | |
| Minimum setup time | $t_s$ | | See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1 | 1.2 | 20.0 | — | ns |
| | | | | 1.5 ± 0.1 | 7.5 | — | |
| | | | | 1.8 ± 0.15 | 2.5 | — | |
| | | | | 2.5 ± 0.2 | 1.5 | — | |
| | | | | 3.3 ± 0.3 | 1.5 | — | |
| Minimum hold time | $t_h$ | | See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1 | 1.2 | 8.0 | — | ns |
| | | | | 1.5 ± 0.5 | 3.0 | — | |
| | | | | 1.8 ± 0.15 | 1.0 | — | |
| | | | | 2.5 ± 0.2 | 1.0 | — | |
| | | | | 3.3 ± 0.3 | 1.0 | — | |
| Output skew | $t_{osLH}$,$t_{osHL}$ | (Note 1) | — | 1.2 | — | 1.5 | ns |
| | | | | 1.5 ± 0.1 | — | 1.5 | |
| | | | | 1.8 ± 0.15 | — | 0.5 | |
| | | | | 2.5 ± 0.2 | — | 0.5 | |
| | | | | 3.3 ± 0.3 | — | 0.5 | |

Note 1: Parameter guaranteed by design. ($t_{osLH}$ = $|t_{PLH}m-t_{PLH}n|$, $t_{osHL}$ = $|t_{PHL}m-t_{PHL}n|$)

## 12.4. AC Characteristics (Note) (Unless otherwise specified, $T_a$ = -40 to 125 °C)

| Characteristics | Symbol | Note | Test Condition | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| Maximum clock frequency | $f_{MAX}$ | | See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1 | 1.2 | 30 | — | MHz |
| | | | | 1.5 ± 0.1 | 70 | — | |
| | | | | 1.8 ± 0.15 | 80 | — | |
| | | | | 2.5 ± 0.2 | 150 | — | |
| | | | | 3.3 ± 0.3 | 200 | — | |
| Propagation delay time (CK-Q) | $t_{PLH}$,$t_{PHL}$ | | See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1 | 1.2 | 1.5 | 63.0 | ns |
| | | | | 1.5 ± 0.1 | 1.0 | 24.4 | |
| | | | | 1.8 ± 0.15 | 1.5 | 11.4 | |
| | | | | 2.5 ± 0.2 | 0.8 | 5.7 | |
| | | | | 3.3 ± 0.3 | 0.6 | 5.0 | |
| 3-state output enable time | $t_{PZL}$,$t_{PZH}$ | | See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.2, Table 12.8.1 | 1.2 | 1.5 | 60.0 | ns |
| | | | | 1.5 ± 0.1 | 1.0 | 23.2 | |
| | | | | 1.8 ± 0.15 | 1.5 | 11.6 | |
| | | | | 2.5 ± 0.2 | 0.8 | 6.5 | |
| | | | | 3.3 ± 0.3 | 0.6 | 5.4 | |
| 3-state output disable time | $t_{PLZ}$,$t_{PHZ}$ | | See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.2, Table 12.8.1 | 1.2 | 1.5 | 41.5 | ns |
| | | | | 1.5 ± 0.1 | 1.0 | 15.6 | |
| | | | | 1.8 ± 0.15 | 1.5 | 7.8 | |
| | | | | 2.5 ± 0.2 | 0.8 | 4.4 | |
| | | | | 3.3 ± 0.3 | 0.6 | 4.0 | |
| Minimum pulse width (CK) | $t_{w(L)}$,$t_{w(H)}$ | | See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1 | 1.2 | 26.0 | — | ns |
| | | | | 1.5 ± 0.1 | 8.7 | — | |
| | | | | 1.8 ± 0.15 | 4.4 | — | |
| | | | | 2.5 ± 0.2 | 1.7 | — | |
| | | | | 3.3 ± 0.3 | 1.7 | — | |
| Minimum setup time | $t_s$ | | See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1 | 1.2 | 21.0 | — | ns |
| | | | | 1.5 ± 0.1 | 7.9 | — | |
| | | | | 1.8 ± 0.15 | 2.7 | — | |
| | | | | 2.5 ± 0.2 | 1.6 | — | |
| | | | | 3.3 ± 0.3 | 1.6 | — | |
| Minimum hold time | $t_h$ | | See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1 | 1.2 | 8.4 | — | ns |
| | | | | 1.5 ± 0.1 | 3.2 | — | |
| | | | | 1.8 ± 0.15 | 1.1 | — | |
| | | | | 2.5 ± 0.2 | 1.1 | — | |
| | | | | 3.3 ± 0.3 | 1.1 | — | |
| Output skew | $t_{osLH}$,$t_{osHL}$ | (Note 1) | — | 1.2 | — | 2.0 | ns |
| | | | | 1.5 ± 0.1 | — | 2.0 | |
| | | | | 1.8 ± 0.15 | — | 1.0 | |
| | | | | 2.5 ± 0.2 | — | 1.0 | |
| | | | | 3.3 ± 0.3 | — | 1.0 | |

Note: Operating Range spec of $T_{opr}$ = -40 °C to 125 °C is applicable only for the products which manufactured after April 2020.

Note 1: Parameter guaranteed by design. ($t_{osLH}$ = $|t_{PLH}m-t_{PLH}n|$, $t_{osHL}$ = $|t_{PHL}m-t_{PHL}n|$)

## 12.5. Dynamic Switching Characteristics (Note) (Unless otherwise specified, $T_a$ = 25°C, Input: $t_r = t_f$ = 2.0 ns, $C_L$ = 30 pF)

| Characteristics | Symbol | Test Condition | $V_{CC}$ (V) | Typ. | Unit |
|---|---|---|---|---|---|
| Quiet output maximum dynamic $V_{OL}$ | $V_{OLP}$ | $V_{IH}$ = 1.8 V, $V_{IL}$ = 0 V | 1.8 | 0.25 | V |
| | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V | 2.5 | 0.6 | |
| | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V | 3.3 | 0.8 | |
| Quiet output minimum dynamic $V_{OL}$ | $V_{OLV}$ | $V_{IH}$ = 1.8 V, $V_{IL}$ = 0 V | 1.8 | -0.25 | V |
| | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V | 2.5 | -0.6 | |
| | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V | 3.3 | -0.8 | |
| Quiet output minimum dynamic $V_{OH}$ | $V_{OHV}$ | $V_{IH}$ = 1.8 V, $V_{IL}$ = 0 V | 1.8 | 1.5 | V |
| | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V | 2.5 | 1.9 | |
| | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V | 3.3 | 2.2 | |

Note 1: Parameter guaranteed by design.

## 12.6. Capacitive Characteristics (Unless otherwise specified, $T_a$ = 25 °C)

| Characteristics | Symbol | Note | Test Condition | $V_{CC}$ (V) | Typ. | Unit |
|---|---|---|---|---|---|---|
| Input capacitance | $C_{IN}$ | | — | 1.8, 2.5, 3.3 | 6 | pF |
| Output capacitance | $C_{OUT}$ | | — | 1.8, 2.5, 3.3 | 7 | pF |
| Power dissipation capacitance | $C_{PD}$ | (Note 1) | $f_{IN}$ = 10 MHz | 1.8, 2.5, 3.3 | 20 | pF |

Note 1: $C_{PD}$ is defined as the value of the internal equivalent capacitance which is calculated from the operating current consumption without load. Average operating current can be obtained by the equation.

$I_{CC}(opr) = C_{PD} \times V_{CC} \times f_{IN} + I_{CC}/8$ (per 1 gate)

## 12.7. AC Test Circuit

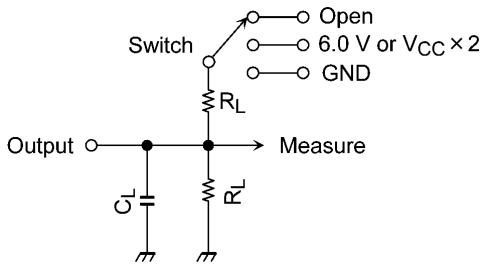



**Table 12.7.1 Parameter for AC Test Circuit**

| Parameter | Switch | Test Condition |
|---|---|---|
| $t_{PLH}$, $t_{PHL}$ | OPEN | — |
| $t_{PLZ}$, $t_{PZL}$ | 6.0 V | $V_{CC}$ = 3.3 ± 0.3 V |
| | $V_{CC}$ × 2 | $V_{CC}$ = 2.5 ± 0.2 V |
| | | $V_{CC}$ = 1.8 ± 0.15 V |
| | | $V_{CC}$ = 1.5 ± 0.1 V |
| | | $V_{CC}$ = 1.2 V |
| $t_{PHZ}$, $t_{PZH}$ | GND | — |

## 12.8. AC Waveform

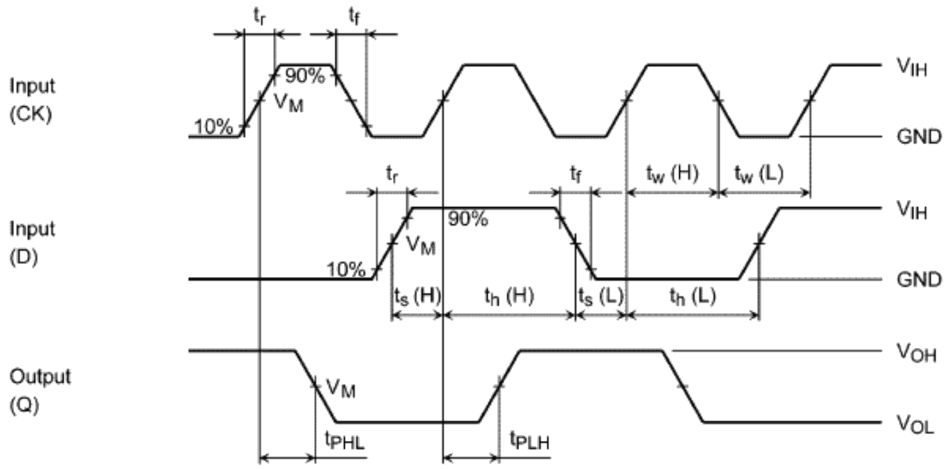



Fig. 12.8.1 $t_{PLH}$, $t_{PHL}$, $t_w$, $t_s$, $t_h$

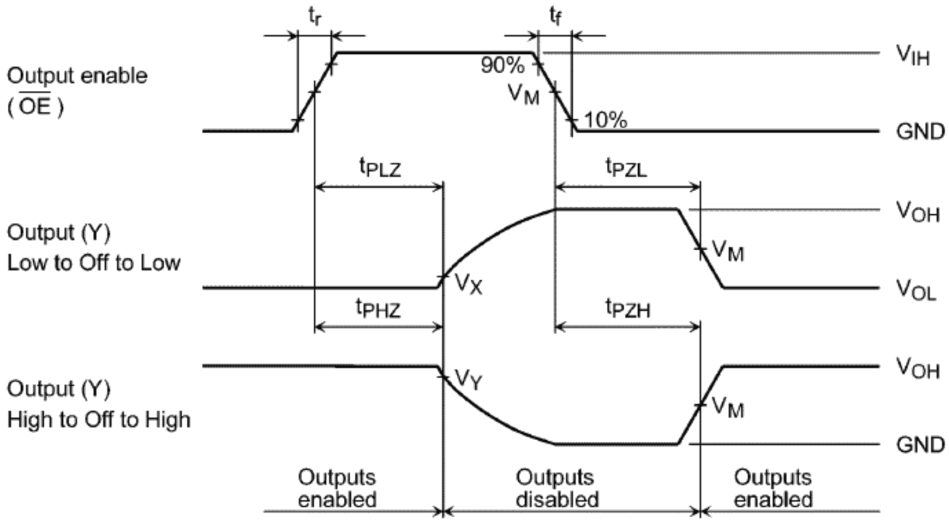


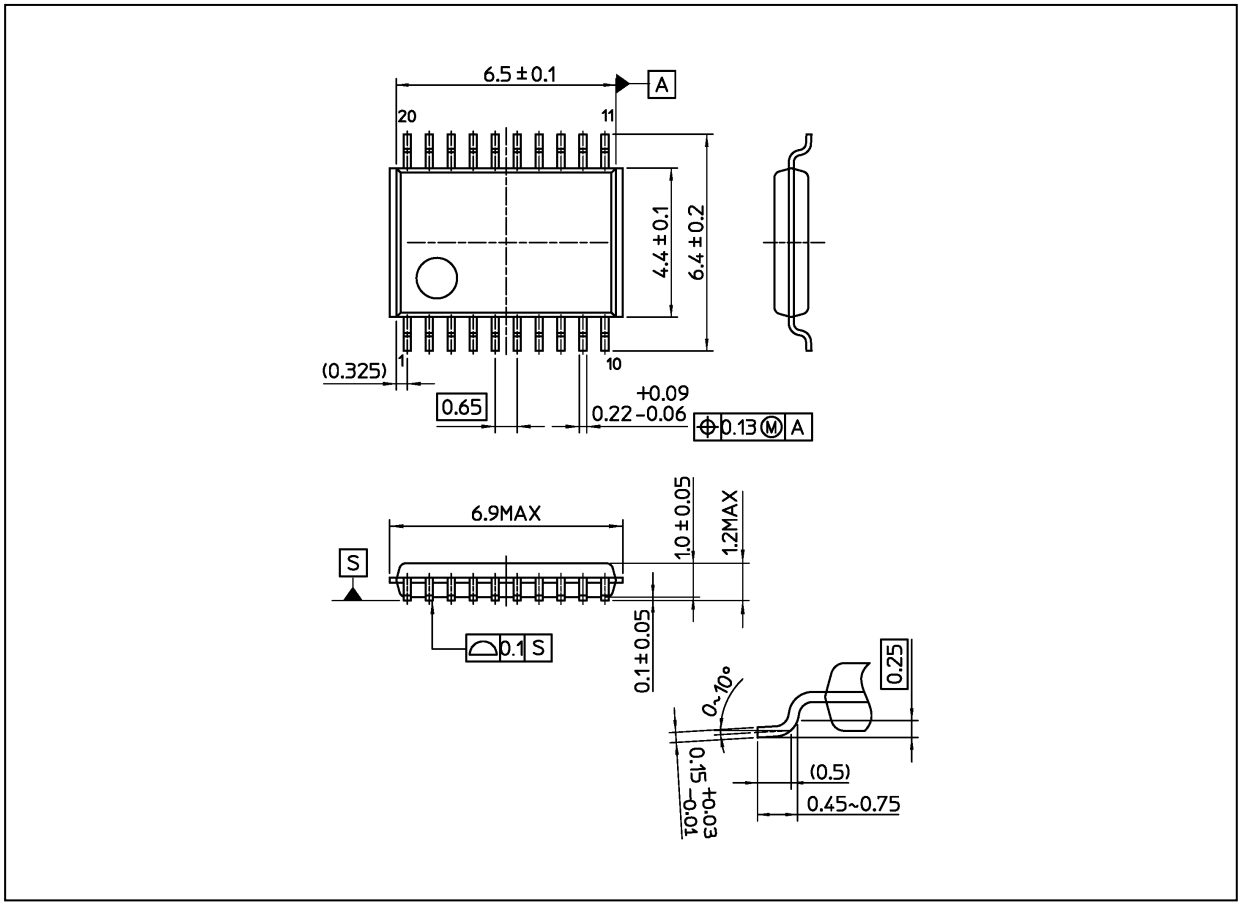

Fig. 12.8.2 $t_{PLZ}$, $t_{PHZ}$, $t_{PZL}$, $t_{PZH}$

**Table 12.8.1 AC Waveform Symbols**

| | Symbol | $V_{CC}$ = 3.3 ± 0.3 V | $V_{CC}$ = 2.5 ± 0.2 V<br>$V_{CC}$ = 1.8 ± 0.15 V | $V_{CC}$ = 1.5 ± 0.1 V<br>$V_{CC}$ = 1.2 V |
|---|---|---|---|---|
| Input | $V_{IH}$ | 2.7 V | $V_{CC}$ | $V_{CC}$ |
| | $V_M$ | 1.5 V | $V_{CC}$/2 | $V_{CC}$/2 |
| | $t_r$, $t_f$ | 2.0 ns | 2.0 ns | 2.0 ns |
| Output | $V_M$ | 1.5 V | $V_{CC}$/2 | $V_{CC}$/2 |
| | $V_X$ | $V_{OL}$ + 0.3 V | $V_{OL}$ + 0.15 V | $V_{OL}$ + 0.15 V |
| | $V_Y$ | $V_{OH}$ - 0.3 V | $V_{OH}$ - 0.15 V | $V_{OH}$ - 0.15 V |
| Load | $C_L$ | 30 pF | 30 pF | 15 pF |
| | $R_L$ | 500 Ω | 500 Ω | 2 kΩ |

## Package Dimensions

Unit: mm




Weight: 0.08 g (typ.)

| Package Name(s) |
| --- |
| Nickname: TSSOP20 |

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